SEA ICE STUDIES IN THE SPITSBERGEN-GREENLAND AREA

Investigation No 28 540

2nd quarterly report

from

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February 1976

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ABSTRACT

The overall objective of this investigation is to utilize LANDSAT data to study sea ice in general and in the Svalbard-Greenland area in particular and to compare the useful ness of LANDSAT and weather satellite data (NOAA-2, ESSA-8,etc.) for studying sea ice. The specific objectives are as follows:

1. To develop a technique for forecasting changes in the position and concentration of sea ice in the Svalbard area due to the influence of weather (primarily wind) and ocean currents.
2. To determine the physical characteristics of sea ice and ice boundaries, including statistical data on the dimensions and form of ice floes.
3. To determine ice drift velocities in the East Greenland Current, and thereby obtain an estimate of the outflow of ice from the Arctic Basin.

Although some information have been collected, the material received is too ltd. and so unsystematic in coverage that there has been little progress, regarding the first mentioned objective. For the two other objectives mentioned some achievements have been made. Of the material received three scenes have been favourable for investigation of the physical characteristics of the sea ice, and from 7 scenes it has been possible to identify several floes from day to day and important speed velocities in the passage between Svalbard and Greenland (Fram Strait) have been determined.

Of special interest is the marked correction of the topographic map of the area. The easternmost and not easily accessible island in the Svalbard-archipelago, Kvitøya, thus turn out to be 2.6 times greater than previously believed. According to LANDSAT imageries its area should be about 700 km^2 instead of 270 km^2.

TECHNIQUES

MSS 7 of all the negatives received have been developed in BW paper copies in 1: 1 mill scale. This is for a quick look to study which information may be obtained from a scene.

The MSS 4 have been developed in the same scale for a further study or localization of interesting features. For a study of large scale ice/water contrasts MSS 7 gives the best information while MSS 4 gives the best small-scaled information such as unevenesses on an icefield.

From BW MSS 7 ice floes have been traced from one imagery to the next on 7 occasions. Drift velocities and direction as well as the areal divergence have been determined simply by placing a transparent paper over the BW paper copies where selected floes have been traced. An example of imageries used is shown in Fig. 1.

The frequency distribution of the size of the ice floes have been determined from BW 1: 500 000 by a semi-automatic planimeter. An imagery used for this purpose is shown in Fig. 1.

For land mapping purposes the imageries have been enlarged to a suitable size and then transferred to a map with a pantograph.

For the current investigation of the Svalbard area at Norwegian Polar Institute some of the scenes have been selected for a closer investigation in an additive colour viewer. Near Greenland and north of Svalbard we know that multi-year drift ice passes by one year old land fast ice. The same viewer will be used to increase contrast between land and sea through relatively thin clouds for mapping, and to distinguish between bare rocks and shadows from clouds. The distribution of cold and warm waters and the biomass will also be studied by the same method.

ACCOMPLISHMENTS

There are some specific new information accomplished in the present LANDSAT investigation which will be closer described below.

Drift velocities, direction and divergence.

The determined drift velocities, directions and areal divergence are given in Fig. 2. The information given by this figure can be compared with the drift determination which previously have been made from the ESSA satellites (Vinje (1968-74)). The latter estimations are shown in Fig. 3. From a comparison it can be seen that the velocities obtained from LANDSAT are considerably higher than those determined from ESSA, 10-15 km/24h

versus 20-30 km/24h. There may also, according to LANDSAT, sometimes be local east-west components in the ice drift which in character agree with observations last summer from two NIMBUS-6 automatic stations which the Norwegian Polar Institute placed on ice floes in that area (Vinje (1975a)). It can be mentioned that the use of NIMBUS-6 ice drift stations will continue and be increased in the area from April this year.

The new information from the LANDSAT indicates that the ice drift in the Fram-Strait - which represents between 70 and 90% of all the ice which is exported from the Arctic Basin - may undergo considerable variations from year to year.

Frequency distribution of the size of ice floes.

Three scenes have been favourable for investigation of the physical characteristics of sea ice. In Fig. 4 is shown the positions of the imageries considered as well as the corresponding frequency distribution of ice floes of different seize. The figure indicates that there is a bimodal distribution with a secondary relatively high occurrence of floes of about 60 km^2. The bimodal tendency is most pronounced in the marginal area near the ice border.

Land map improvements.

From visits as well as from inspection of the weather satellites it has been known that Kvitøya, cf. Fig. 5, should be larger than was indicated on earlier maps. This has now been demonstrated in a spectacular way by the LANDSAT imageries (2077-11335) and (2201-11220). An estimation shows that the area of the island should be 700 km^2 instead of 270 km^2 as previously believed. As will also be seen from Fig. 5, the smaller island named Storøya has got a new position.

Comparison between LANDSAT and weather satellite data.

For four LANDSAT scenes it has been possible to compare the ice borders with those obtained from the weather satellites. It turns out that where there is a small cloud cover, the borders are in agreement. For conditions with high clod cover, however, it is evident that the weather satellite is inferior to the LANDSAT. On August 26th, for instance, the LANDSAT imagery 2216-14303 indicates an ice cover of 3/8 through a thin cloudveil. From the weather satellite based ice charts the concentration was estimated

to be 6-7/8, i.e. a 50% difference.

SIGNIFICANT RESULTS

The present investigation gives information which shows unexpected great variations in the drift velocity of the ice in the Fram Strait. The present investigation also gives information of future measuring schemes for monitoring the outflow of sea ice from the Arctic Basin, which through the Fram Strait amounts to 70-90% of the total ice export.

Another significant result is the land map improvements which has been achieved by LANDSAT in the eastern part of the Svalbard-archipelago. Aircraft missions for land mapping of the eastern part is planned for 1977. It is neceasary with a stand-by of an aircraft the whole summer to take advantage of clear weather conditions. Such a mission therefore costs about $ 100 000 and it becomes obvious that every new information, such as that from LANDSAT is of greatest importance.

DATA QUALITY AND DELIVERY

The quality of the data received is in general excellent. About 15% of the material cannot be used due to very high cloud cover. Another 15% shows scenes from Greenland where the sea is not visible. The "density" of the negatives is not always the same, and experimentation is necessary to obtain the best BW paper copies of the negatives.

After the clearing of the misunderstanding in the delivery from NOAA at the beginning of the coverage period, all orders have since been handled expeditiously.

The material required in 1975 was unsystematically collected. The objectives of the present investigation can be accomplished only if 2-3 days repetitive coverage of an area is given.

RECOMMENDATIONS

Due to the high latitudes of the test area there will be a maximum overlapping from day to day. This is a special advantage which it was the intention to utilize in the present investigation. Even after three days there will be an overlapping of about 60% of the first image in a three days series. It is emphasized that all the three main objectives of this investigation could be achieved if a maximum acquisition of images could be done daily for fair-weather periods of 2-3 days. It is hoped that attention

is paid to this very important point when scheduling the acquisition of imagery over the test area in 1976. It is of course of great importance that the chosen fair-weather periods should be spread over the approved coverage period which is from March 1st to September 30th.

Would it be convenient or/and possible with an agreement so that the Norwegian Meteorological Institute which is in charge of the weather forecasting for the test area, informed NASA about suitable fair-weather periods?

CONCLUSIONS

The LANDSAT data have demonstrated their unique utility within a number of diciplines. This becomes of special importance for institutes which are in charge of investigations in not easily accessible polar areas. In the daily work with sea ice the LANDSAT imageries constitute a source for unique information, which also will become an important source of reference in the future.

REFERENCES

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VINJE, T.E. 1968-74: Annual articles on sea ice and drift velocities in Norsk Polarinstitutts Årbok, Oslo

" (1975a): The drift of NIMBUS-6 automatic data collection platforms in ice-covered waters. Norsk Polarinstitutts Årbok 1975 (In print).

" (1975b): On the ice conditions in the marginal seas of the Arctic in the European sector in the period 1967-1975. Norsk Polarinstitutts Årbok 1975 (In print).

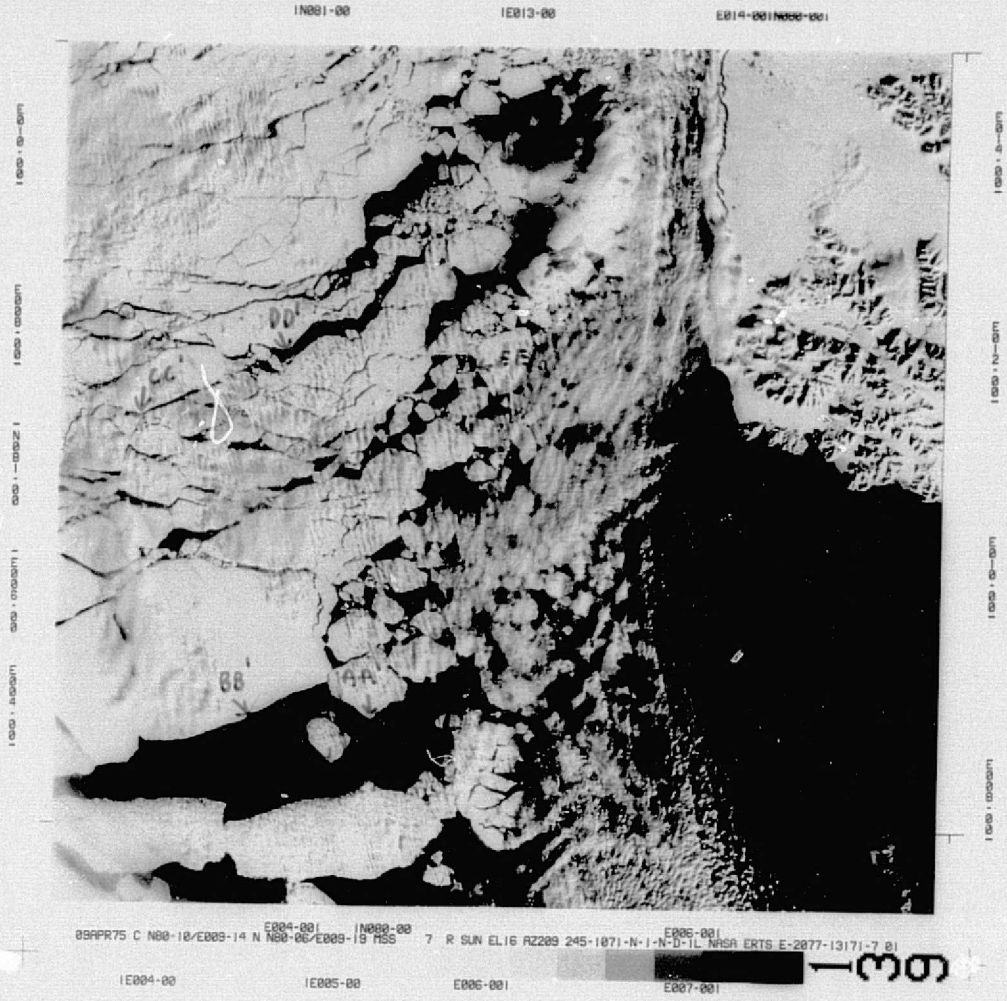
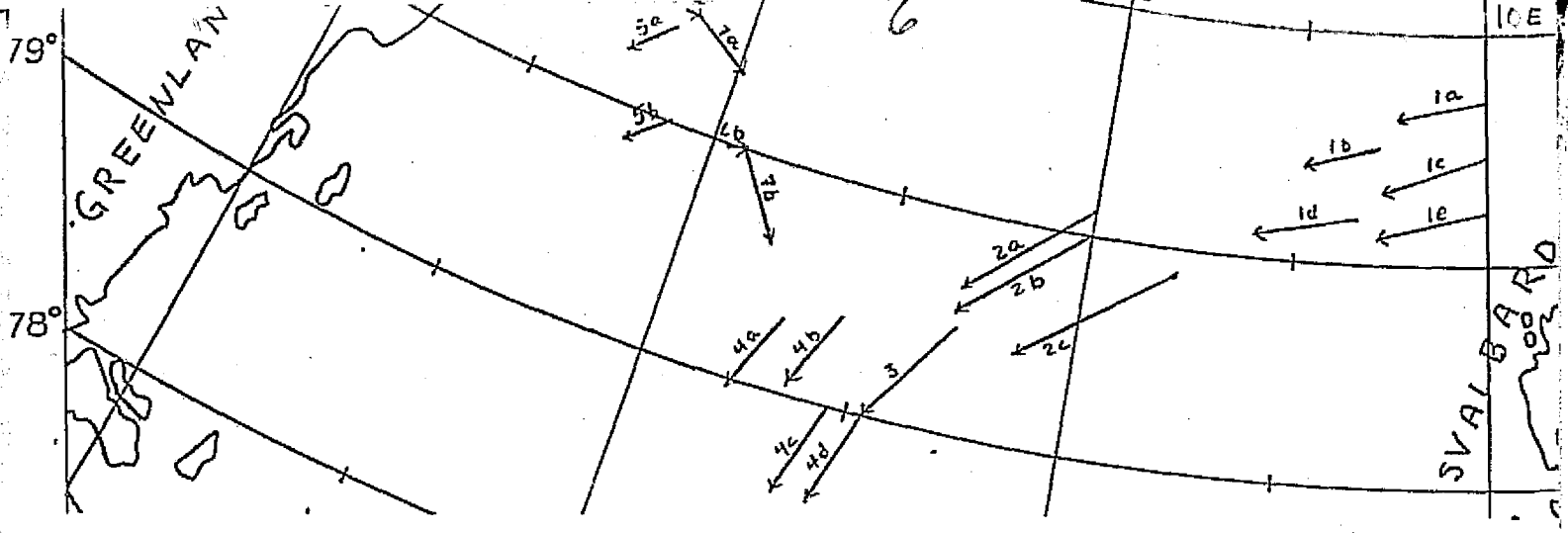


Fig. 1



Ref.	LANDSAT ID	Period	Velocity km/24h	Divergence sec^{-1}
1	2077-13171..2079-13283	9 APR -11 APR-75	22	$-1.0 \cdot 10^{-6}$
2	2077-13173..2081-13403	9 APR -13 APR	22 - 27	$-3.0 \cdot 10^{-6}$
3	2077-13173..2079-13292	9 APR -11 APR	22 - 27	$-3.0 \cdot 10^{-6}$
4	2077-13292..2081-13403	11 APR -13 APR	22 - 27	$-3.0 \cdot 10^{-6}$
5	2076-14544..2077-15002	8 APR - 9 APR	23 - 30	$-1.0 \cdot 10^{-5}$
6	2216-14303..2217-14361	26 AUG -27 AUG	12 - 20	
7	2217-14361..2229-14021	27 AUG - 8 SEP-75	6 - 9	$2.6 \cdot 10^{-5}$

Fig.2

LANDSAT based drift and divergence calculations.

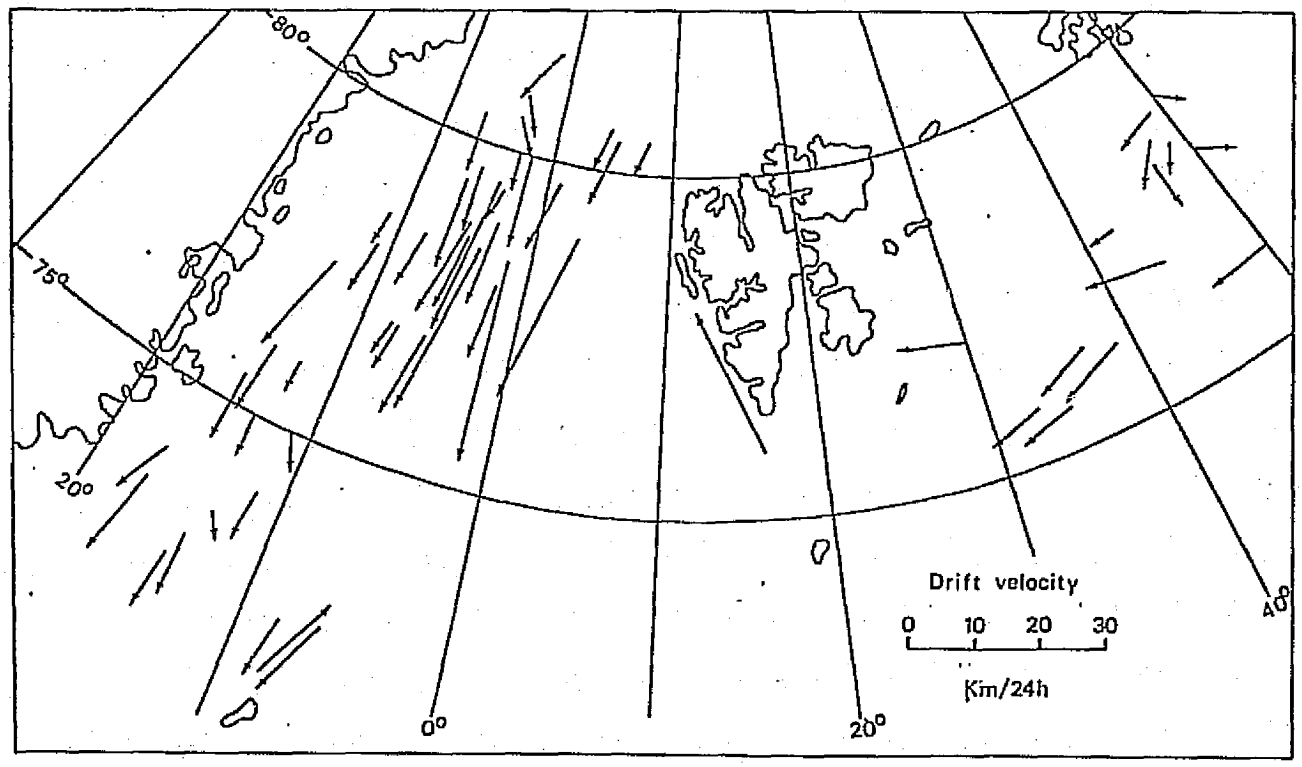
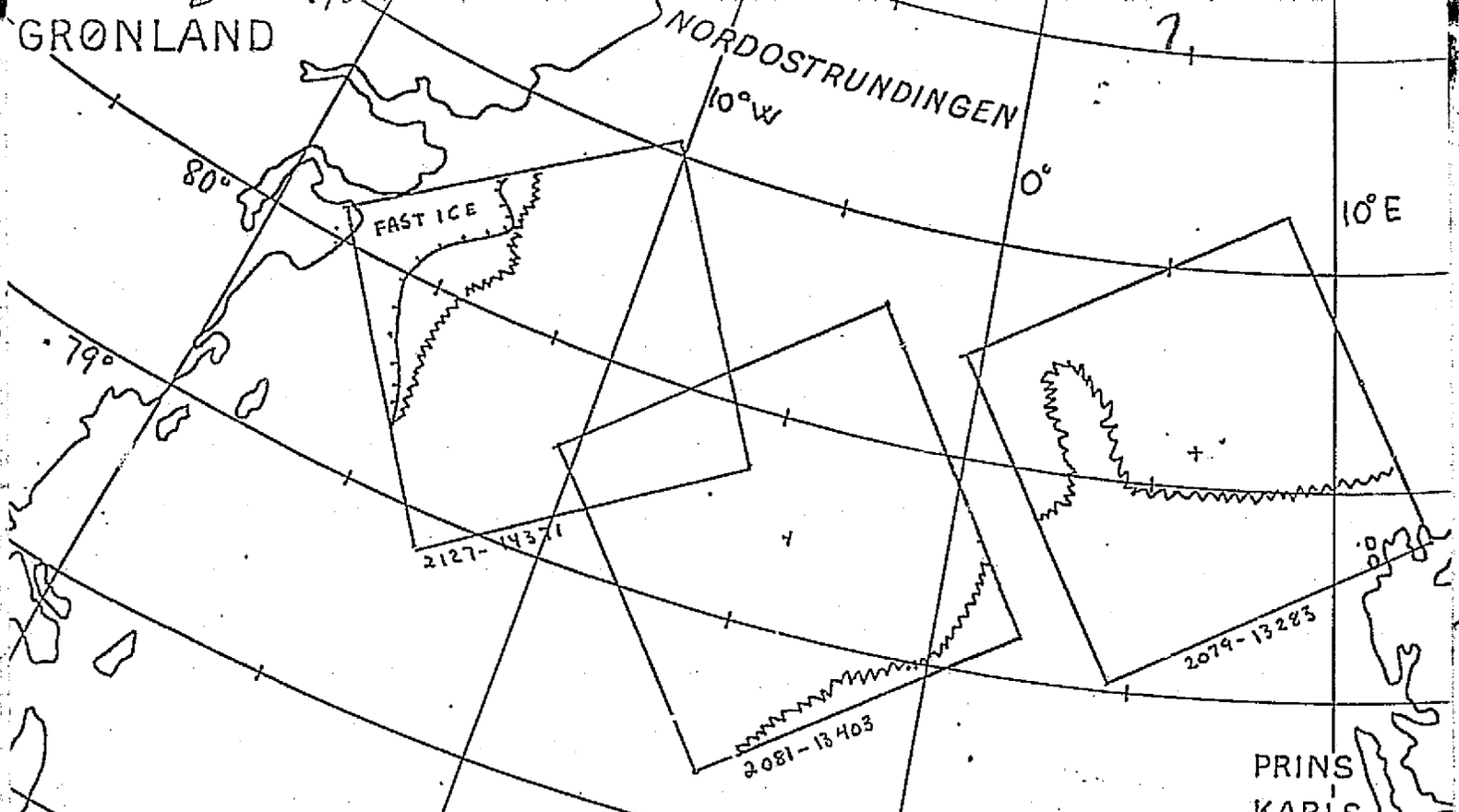


Fig.3

Drift of giant floes determined from weather satellite imageries. (Vinje (1968-74)).North of Jan Mayen is indicated the drift of M/S "POLARBJØRN" which was beset for 22 days in April 1969.



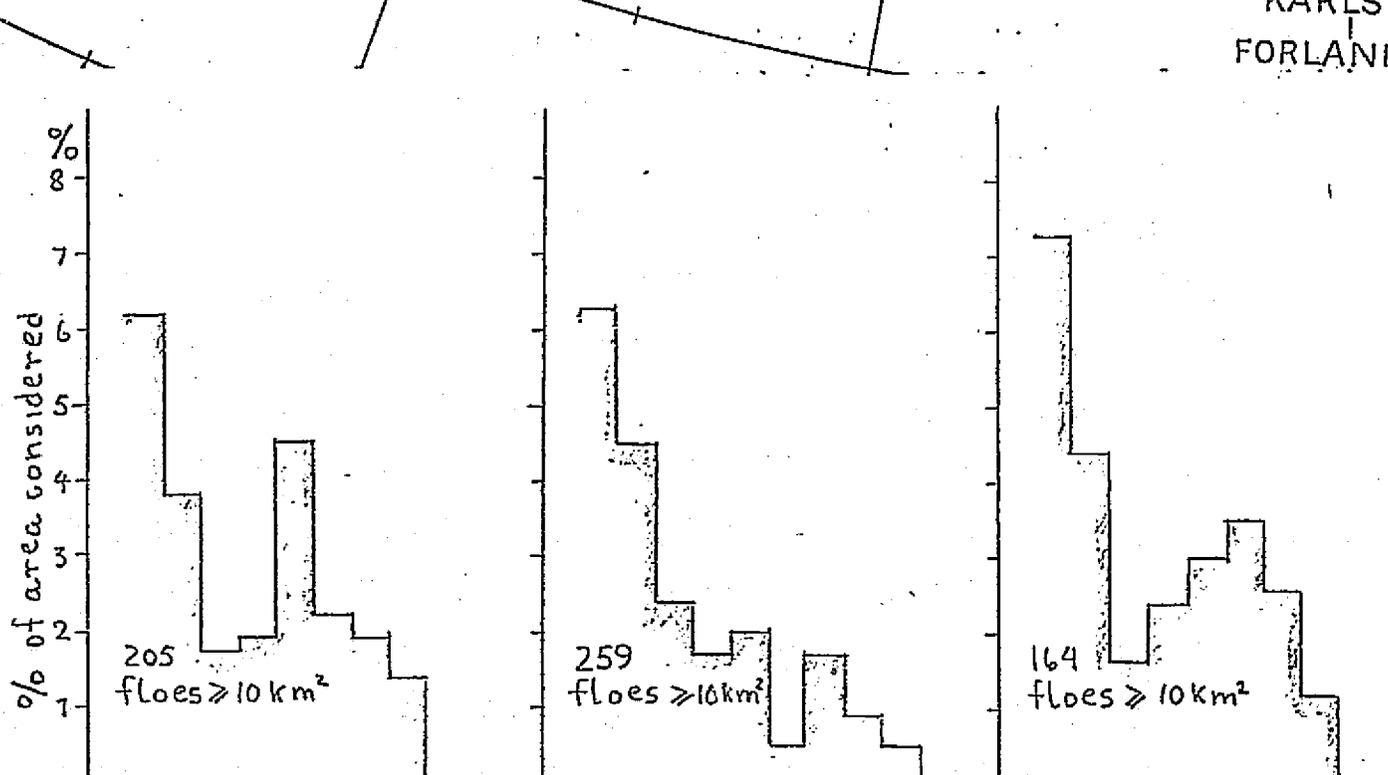


Fig.4

Frequency distribution of ice floe of different seize. Note the indication of a bimodal distribution.

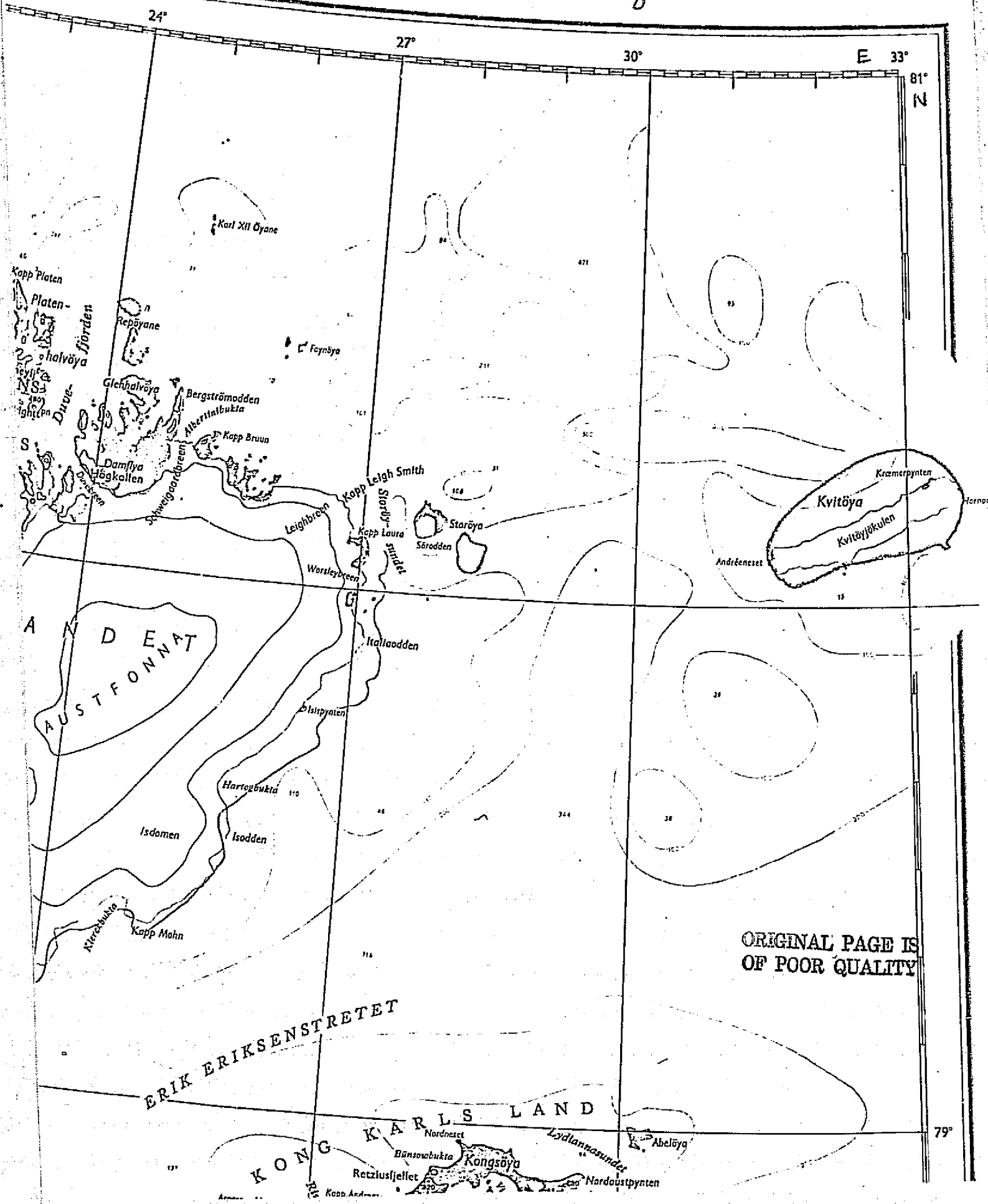


Fig. 5
Corrections obtained on land maps from LANDSAT-2, east of 28°E, and from LANDSAT-1 west of this longitude.